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(54) Abstract Title
Synchronising a local reference frequency in a mobile station

(57) A current ambient condition, for example temperature, of a mobile station is measured and a stored data list is used to determine the frequency variance of a local oscillator. A method for synchronising the local frequency of the mobile station is selected according to the magnitude of the frequency variance. The oscillator may be synchronised using a long code mask symbol (LCMS) transmitted in the broadcast channel. The different methods of synchronising may include the use of more robust algorithms and increasing the bandwidth of the filtering that is applied to an input network signal in the case of large frequency variances.
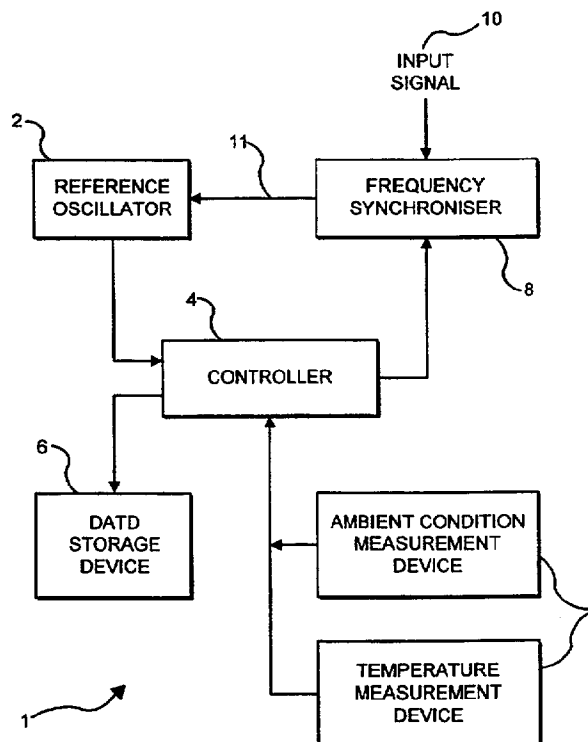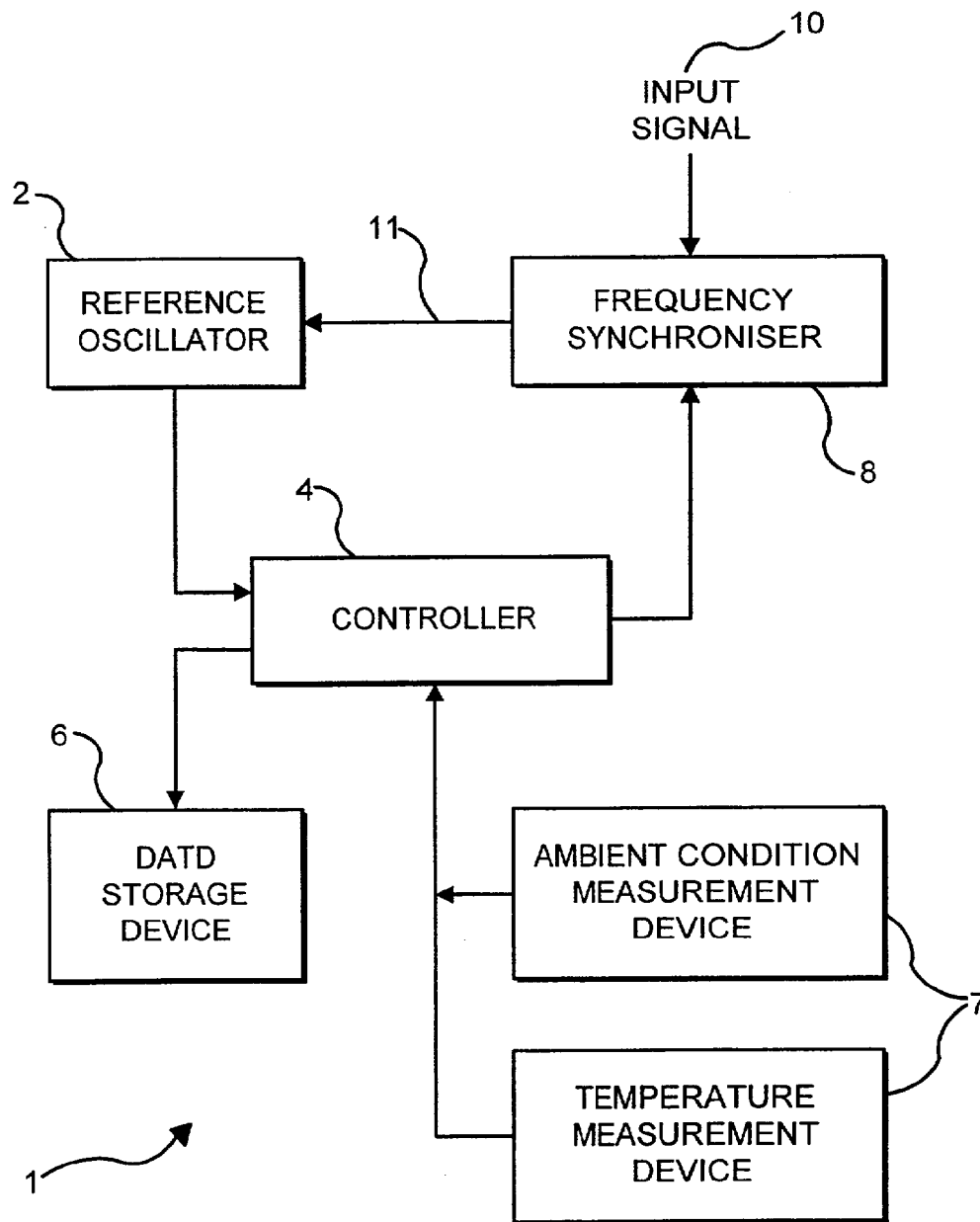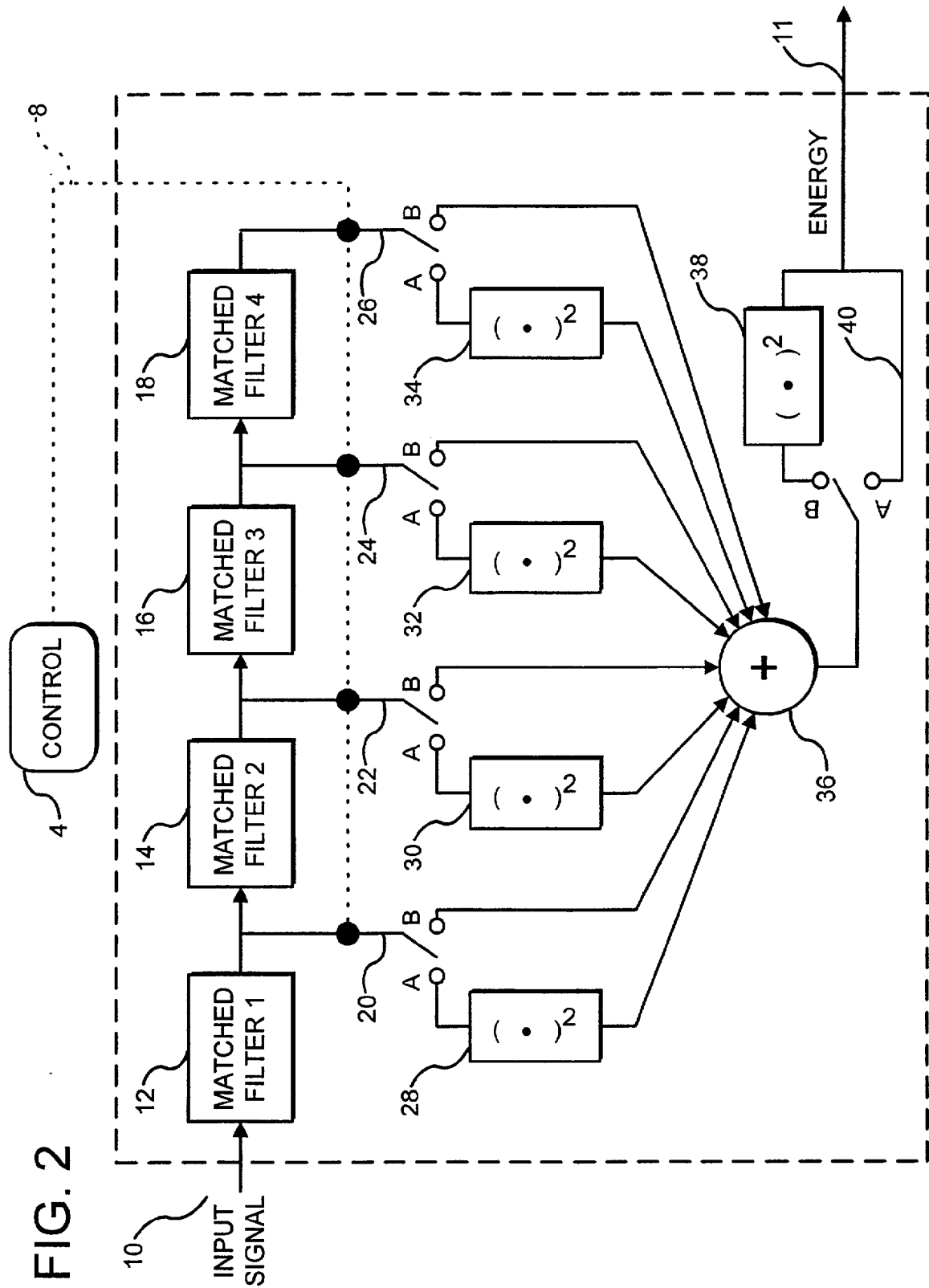
FIG. 1

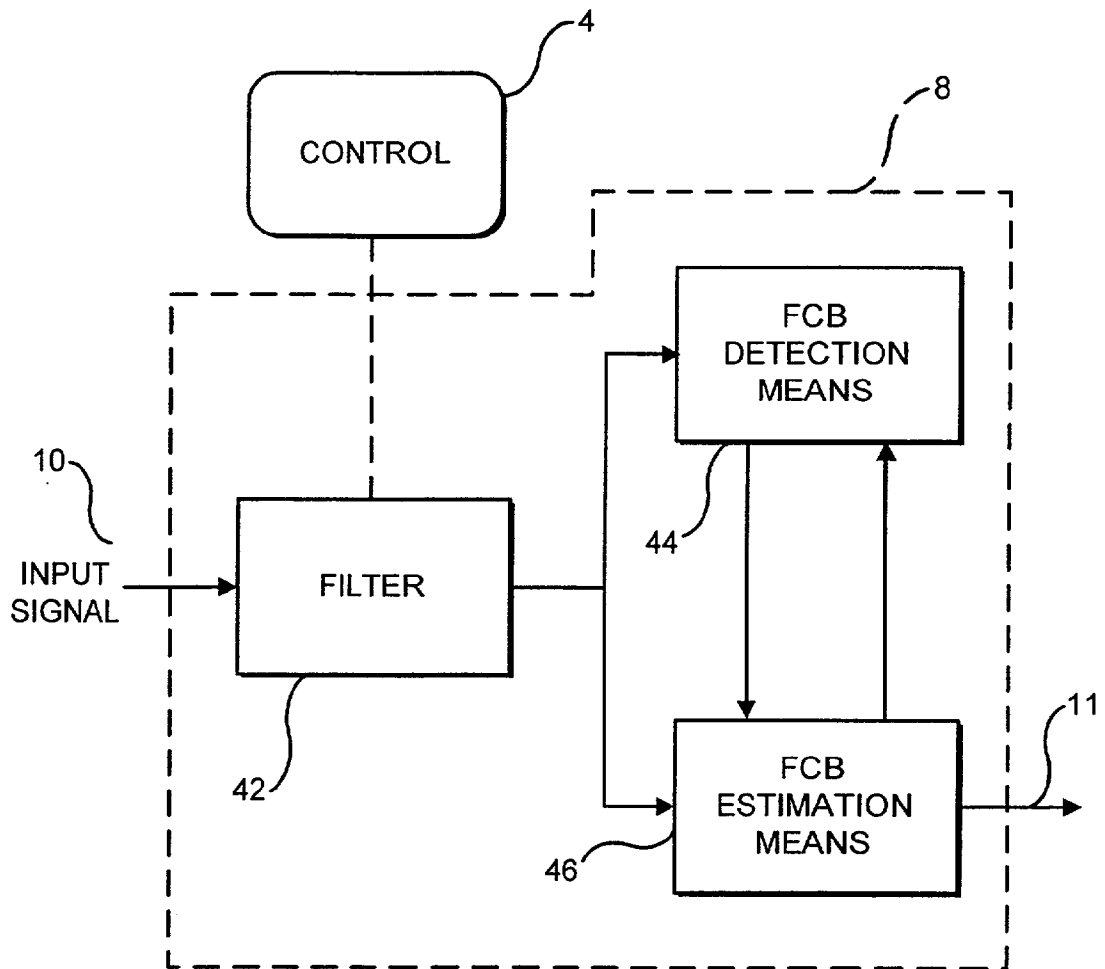GB 2 354 403 A

FIG. 1

FIG. 2

FIG. 3

COMMUNICATION SYSTEMS

The present invention relates to communication systems
and in particular to radio frequency communication
5   systems in which mobile stations communicate with base
stations.

BACKGROUND OF THE INVENTION

10   In a communication system including base stations and
mobile stations which communicate with the base
stations, the mobile stations include reference
oscillators which are used to decode received
transmissions from base stations and to transmit
15   signals to the base stations. The mobile station
reference oscillator provides a local frequency to the
mobile station which, in theory, should be synchronised
with and equal to the network frequency. However, due
to inaccuracies in the crystal oscillators usually used
20   in mobile stations, it is necessary for the mobile
station to adjust its local frequency so that it is
synchronised with the network frequency.
Conventionally, complex algorithms are used which can
operate only with high signal to noise ratios of the
25   input network signal. The main cause of oscillator
instability is temperature change and so temperature
compensated high accuracy crystal oscillators can be
provided. However, such a solution is considered to be
expensive.
30

In addition to initial frequency synchronisation, a
synchronised mobile station must update its local
frequency to the network frequency because of the
variance of local reference frequency with temperature.

Whilst the mobile station is in an active mode and is communicating with the base station, the mobile station has constant access to frequency and time reference information from the network, and can use this to make the required adjustments to local frequency. However, when a mobile station is in an idle mode, access to network information is limited. In an idle mode, the mobile station will occasionally be activated in order to receive paging signals from the network. In order to preserve battery power, the mobile station must only become active for a short amount of time. It is therefore necessary that the frequency and time reference estimation is carried out in a short amount of time. However, large estimation errors can occur when large variations of frequencies combine with low signal to noise ratios and short estimation periods.

In the proposed IMT 2000 system based on a wide band code division multiple access (W-CDMA) system-time boundary reference synchronization is required. Synchronizing to a time reference is dependent upon the accuracy of the local crystal frequency, and so a mobile station initially synchronises to the network by looking for a symbol, the so-called long code mask symbol (LCMS) which is transmitted in the broadcast channel (BCCH). The received signal is filtered by matched filters and peaks in the output of those filters provide the location of the LCMS. However, if the local oscillator crystal is inaccurate, for example ± 10ppm, the frequency deviation between the local crystal and the reference can be up to plus or minus 20kHz. This is due to the carrier frequency being 2GHz. Since the symbol rate in the BCCH is 16kHz the symbol rotates

450° (360° x 10ppm x 2GHz/16kHz) within the symbol duration. Such large rotation results in severe loss of the signal energy at the peaks of the matched filters output. Thus, the LCMS is divided to a number of sequences, for example 4, which are searched separately and the results of the match filters are non-coherently summed. Splitting the LCMS in this way reduces the symbol rotation for that portion of the LCMS. However, dividing the LCMS into four segments can also deteriorate the signal to noise ratio and can cause problems when detecting the full LCMS. The wideband CDMA specification (3rd Generation partnership Project (3GPP) document TS25.201, V2.1.0) describes this system in more detail.

In an example of frequency synchronization, the global system for mobile communications (GSM) system transmits synchronisation information from base stations to mobile stations in terms of a frequency correction burst (FCB) and synchronisation burst (SB). The FCB consists of a pure sinusoid which needs to be detected, and which a mobile station uses to obtain rough time synchronisation to the network as well as to adjust the local frequency reference. The SB is transmitted 8 bursts after the FCB and so detection of the FCB enables the position of the SB to be determined. The FCB can also be used to provide a coarse adjustment of the reference frequency, while the SB is used for fine adjustment. This method is used in the GSM system, a description of which can be found in "The GSM system for mobile communications", by Mouly and Pautet.

There are a number of algorithms used for initial synchronisation of a mobile station to a GSM network.

Since the FCB is a pure sinusoid, a frequency selective
filter is usually used to suppress the noise outside
the frequency zone of interest in order to improve the
signal to noise ratio. This improvement depends on the
5   bandpass of the filter. The narrower the bandpass, the
better the signal to noise ratio. The inaccuracy of
the local crystal (for example 10ppm) however can
effect the frequency of the received FCB. This
frequency can be interpreted with the deviation of +/-
10   9KHz if the carrier frequency is 900MHz. Hence the cut
off frequency of the filter should be greater than
9kHz. In a case of a carrier frequency of 1800MHz or
1900MHz, in the GSM 1800 and 1900 systems, the cutoff
frequency of the filter would need to increase to 18 or
15   19KHz. The limitation of the cut off frequency due to
the inaccuracy of the crystal oscillator therefore
reduces the improvement of signal to noise ratio and
hence reduces the likelihood of fast synchronisation.

20   It is therefore desirable to provide an apparatus in
which synchronisation of the local reference frequency
to the network frequency can be achieved quickly and
with minimum power consumption.

25   SUMMARY OF THE INVENTION

According to one aspect of the present invention, there
is provided a method for synchronising a local
reference frequency in a mobile station, the method
30   including measuring a current ambient condition of the
mobile station and using stored data indicating
variance of the local reference frequency with known
ambient conditions to determine the method by which the
local reference frequency is synchronised.

According to another aspect of the present invention, there is provided an apparatus for communicating with a wireless network having a network reference frequency, the apparatus comprising a local oscillator for producing a signal having a local reference frequency, a storage device for storing data indicating the variance of the local reference frequency with changes in a known ambient condition of the apparatus, control means for adjusting the local frequency, and measurement means for measuring the ambient condition of the apparatus and supplying that measurement to the control means, wherein the control means is operable to retrieve data stored in the storage device which is indicated by the received measurement, and to adjust the local reference frequency in accordance with an adjustment method determined by the retrieved data.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram illustrating a mobile station operable in accordance with one aspect of the present invention;

Figure 2 illustrates in more detail a first frequency synchroniser of the mobile station in Figure 1; and

Figure 3 illustrates in more detail a second frequency synchroniser for use in the mobile station of Figure 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a block diagram illustrating a mobile station 1 operable in accordance with the present invention. The mobile station 1 includes a reference

oscillator 2, a controller 4 and a frequency
synchroniser 8. The frequency synchroniser receives an
input signal 10 from the network and, under the control
of the controller 4, adjusts the reference oscillator
5   by way of an output signal 11. In this way, the
controller 4 is able to adjust the reference oscillator
frequency so as to synchronise with the network input
signal 10.

10   The mobile station 1 also includes a reference
oscillator data storage unit 6 and a temperature
measurement device 7. The data storage unit 6 is used
to store calibration data relating to the known
inaccuracies of the reference oscillator over a range
15   temperatures. The measurements are preferably updated
in order to reduce the statistical uncertainties of the
stored data. The stored information can be updated
whenever reference information is available from the
network. In this way, the crystal oscillator can be
20   self-calibrating.

The controller 4 receives temperature information from
the temperature measurement device 7. The controller
uses the temperature information to refer to the
25   calibration data stored in the data storage unit 6 in
order to obtain data indicating the actual variance of
the frequency of the local oscillator. The controller
4 can then modify the algorithms for the initial and
maintenance of the frequency and/or time reference
30   synchronisation to the network frequency/time reference
on the basis of the calibration information. This
modification allows the mobile station 1 to operate at
lower signal to noise ratios, or use a less complex
algorithm, or be able to verify an estimate produced by

an existing algorithm.

Thus, a method embodying the present invention enables
the mobile station to determine how far the reference
oscillator must be compensated to synchronise with the
network frequency. For example, if the stored data
indicates that the crystal is likely to be severely
inaccurate, then a more complex and robust algorithm
should be used for the frequency correction. However,
if the stored data indicates that the crystal is
varying only a small amount from the required
frequency, then a simplified, and hence faster,
algorithm can be used.

With the wideband code division multiple access W-CDMA
system described above the use of stored reference
oscillator calibration data can produce reduced
inaccuracy and the detection of the partial LCMS can be
substituted by detection of the entire LCMS in order to
reduce potential symbol rotation. A suitable system
for W-CDMA applications is shown in Figure 2. The
frequency synchroniser 8 comprises a series of matched
filters 12, 14, 16 and 18 each of which produces a
respective output. The controller 4 operates to switch
the outputs of the matched filters, using respective
switches 20, 22, 24 and 26, between non-coherent
averaging and coherent averaging. For non-coherent
averaging, the signals are squared by multipliers 28,
30, 32 and 34, the squared signals added by an adder 36
and the result output as a control signal 11. In the
non-coherent averaging technique, the output is simply
transferred directly to obtain the time boundaries.
For coherent averaging, the sum of the output signals
of the matched filters are summed by the adder 36 and

the result squared before output as a control signal.

The switching between coherent and non-coherent averaging is dependent upon the accuracy of the oscillator. For example, if the accuracy is 10ppm which is outside a desired preselected range of variance, then the switches 20, 22, 24 and 26 are set to position A for non-coherent averaging. However, when the oscillator is within the preselected range, i.e. it is within the range of calibration data stored in the data storage unit, the switches are shifted to position B to provide coherent averaging. In this way, the frequency synthesiser can provide an appropriate control signal dependent upon the actual variance of the oscillator.

For frequency synchronization, for example in the GSM system as described above, a mobile station includes a frequency synchroniser as shown in Figure 3. The synchroniser includes a filter 42 having a controllable cutoff frequency in order to enhance the signal to noise ratio of the device. An FCB detection unit 44 and an FCB estimation unit 46 receive the filter output and operate to provide a control signal for the reference oscillator. When the controller 4 determines, for example by measuring the temperature, that the reference oscillator is within a certain frequency range from the specification value, the cutoff frequency of the filter 42 can be reduced. By reducing the cutoff frequency of the filter 42, the signal-to-noise ratio of the system can be improved. If the oscillator is outside of the range, then the cutoff frequency can be increased.

A mobile station which is not active will usually preserve battery power by entering an idle mode. In an idle mode, the mobile station operates for a small percentage of time in order to determine whether or not it has been paged. During this limited time the mobile station must estimate the network reference frequency and compare it to its own local frequency. Such a frequency adjustment is required since the frequency of the local oscillator will move away from the reference frequency of the network. Using the oscillator calibration system of the present invention, the estimates of network frequency can be evaluated and compared against the stored data in order to determine how far from the desired value is the oscillator frequency.

CLAIMS

1.   A method for synchronising a local reference
frequency in a mobile station, the method including
storing data indicative of the variance of the local
reference frequency with known ambient conditions,
measuring a current ambient condition of the mobile
station and using the stored data to determine the
method by which the local reference frequency is
synchronised.

2.   A method as claimed in claim 1, wherein the
measured current ambient condition is used to retrieve
data stored in a storage device in the mobile station,
which data relates to the variance of local reference
frequency of the mobile station over a range of known
ambient conditions, the method further comprising
comparing the retrieved data with a predetermined value
range, and if the retrieved data is outside the
predetermined value range, synchronising the local
reference frequency using a first method, or if the
retrieved data is inside the predetermined value range,
synchronising the local reference frequency using a
second method.

3.   A method as claimed in claim 2, wherein the local
reference frequency is synchronised to a wide band co-
division multiple access network reference frequency
and wherein the first method is a non-coherent
averaging method and the second method is a coherent
averaging method.

4.   A method as claimed in claim 2, wherein the local
reference frequency is synchronised to a GSM network

reference frequency, and wherein the first method
includes filtering an input network signal with a
filter having a first bandpass width, and the second
method includes filtering an input network signal with
5   a filter having a second bandpass width, the second
bandpass width being smaller than the first bandpass
width.

5.   An apparatus for communicating with a wireless
10   network having a network reference frequency, the
apparatus comprising a local oscillator for producing a
signal having a local reference frequency, a storage
device for storing data indicative of the variance of
the local reference frequency with known ambient
15   conditions of the apparatus, control means for
adjusting the local frequency, and measurement means
for measuring a current ambient condition of the
apparatus to produce a current ambient condition
measurement and for supplying the current ambient
20   condition measurement to the control means, wherein the
control means is operable to retrieve data stored in
the storage device which data corresponds to the
current ambient condition measurement, and to adjust
the local reference frequency in accordance with an
25   adjustment method determined by the retrieved data.

6.   An apparatus as claimed in claim 5, wherein the
control means comprises first and second adjustment
means, and is operable to select the first adjustment
30   means if the retrieved data is outside a predetermined
range of values, and to select the second adjustment
means if the retrieved data is within the predetermined
range of values, the first and second adjustment means
being operable to adjust the local reference frequency

in accordance with respective methods.

7.   An apparatus as claimed in claim 6, for use in a
wideband code division access communications system,
further comprising a series of four matched filters,
each filter except the first receiving as its input the
output of the previous filter in the series, the first
filter in the series receiving a network reference
frequency signal as its input, each filter providing a
respective output, wherein the first adjustment means
is operable to produce a non-coherent average signal
from the outputs of the matched filters, and the second
adjustment means is operable to produce a coherent
averaged output of the filter outputs.

8.   An apparatus as claimed in claim 6, for use in a
GSM communications network, wherein the first
adjustment means includes a first filter connected to
receive an input network signal, the first filter
having a first bandpass width, and the second
adjustment means includes a second filter connected to
receive an input network signal, the second filter
having a second bandpass width which is smaller than
the first bandpass width, and wherein the outputs of
the first and second filters are connected to a GSM
frequency correction burst estimator and detector
means.

The
Patent
Office

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Application No:	GB 9921978.4	**Examiner:**	Glyn Hughes
Claims searched:	1 to 8	**Date of search:**	21 March 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

    UK Cl (Ed.R): H4L (LDLW, LECY), H3F (FKP)

    Int Cl (Ed.7): H03B 5/04, H03L 1/00, 1/02, H04Q 7/32

Other: Online: WPI, JAPIO, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	WO 96/24986 A1 (MATSUSHITA) see in particular page 23 line 28 to page 25 line 9.	1, 2, 5, 6

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